Activities with Tangram for Learning Mathematics

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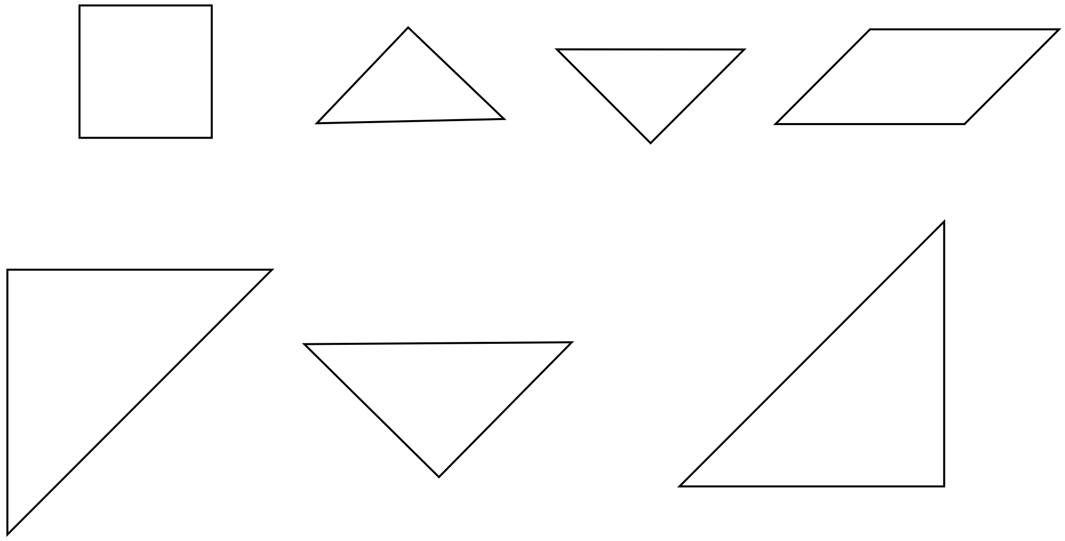
Models and manipulatives are valuable for learning mathematics especially in primary school. These can be used to enhance understanding of concepts, mathematical reasoning, communication and problem solving. These provide opportunities for exploration of ideas, verification of results and creativity. There have been many comprehensive reviews of the research on the use of concrete manipulatives. All have concluded that student achievement is increased as a result of being exposed to concrete materials by teachers. Sowell[1] after analyzing sixty studies between 1954 and 1984 found that the long-term use of concrete instructional materials enhances achievement and improves students' attitudes toward mathematics if the teachers are knowledgeable about the use of concrete materials[1]. Lack of commercial availability or adequate finances can be overcome by using manipulatives that can be made with readily available and cheap materials. In this paper we suggest some activities with tangram that can be used for enhancing spatial visualization, understanding of concepts of symmetry, transformations, tiling; perimeter, area, fractions and mathematical reasoning, communication and creativity. The use of tangram to make different objects, people and animals can be integrated with art.

A **tangram** is an old Chinese puzzle and consists of a square cut into seven pieces given below:



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[1] Sowell, E. J. (1989). Effects of manipulative materials in mathematics instruction. **Journal of Research in Mathematics Education, 20,**498—505.

You can buy these or make these pieces by getting photocopies of the figure given in Activity Sheet 1 and pasting on a cardboard, and cutting the pieces. The activities given below may be used for spatial visualization and understanding of concepts of symmetry, transformations, tiling; perimeter, area and fractions and enhancing mathematical reasoning, communication and problem solving. We have restricted to the topics in primary classes in NCERT Syllabus 2005.

Geometrical Shapes

Hold a tangram piece and ask students to hold up the same shape. Ask students what they know about the shape and write their responses on the blackboard. Follow the same procedure for the square and parallelogram.
Ask students to trace the tangram pieces on a paper. Exchange papers with a partner and Match the tangram pieces with the shapes drawn on paper.
Sort tangram pieces by shape
Sort tangram pieces by number of sides

Transformations

Slides move figures along any direction without changing its shape and size.
Place a square in the middle of your notebook and slide it in various directions and trace the square.
Repeat it with a larger triangle and parallelogram.
Place a dot in the center of a piece of paper. Trace or draw five triangles around the dot to form a flower.

Flips

A **flip** produces a mirror image of a figure. It is also called a reflection.
Trace around a square tangram piece, flip it along a side horizontally and vertically and trace around them. Compare your figure with students sitting next to you, what do you notice?
Repeat it for a medium triangle, and the parallelogram tangram pieces.

Turns

A **Turn** is rotating a figure about a point. Trace different tangram pieces and cut the figure. Hold a pin on a corner of a square and rotate it. Trace around after rotating part of a full turn.
Does the rotated square have the same length of sides, same shape of corners and area as the square you started with?
Compare your figure with students sitting next to you; how does his rotated figure differ from yours? In what way the two figures are similar?

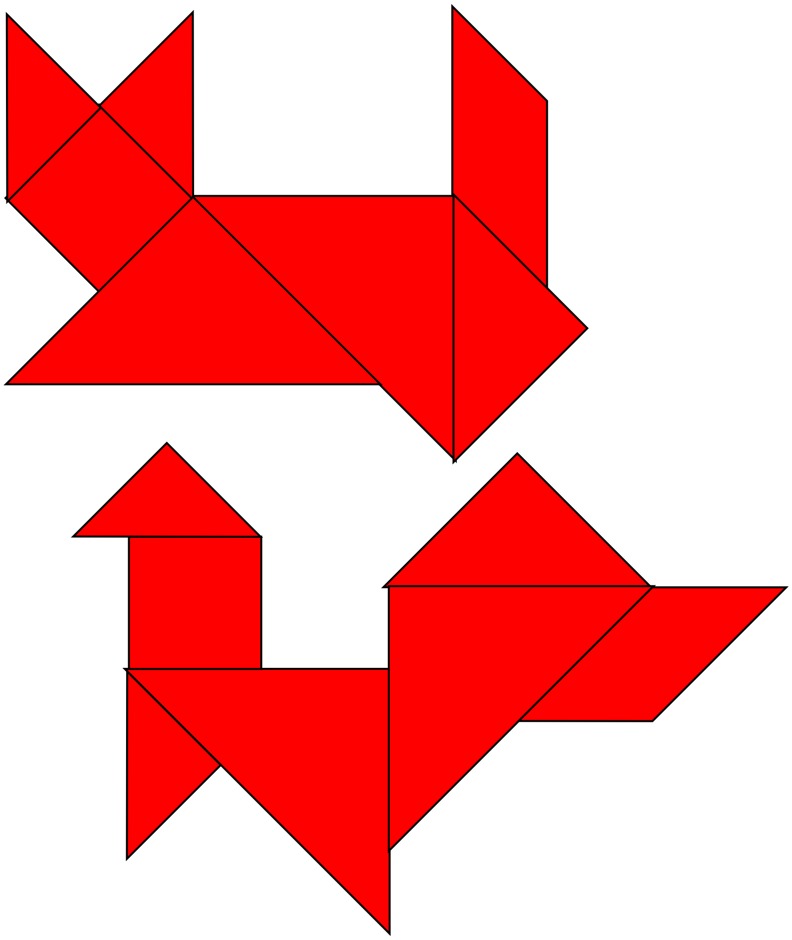
Making different geometrical shapes with tangram pieces

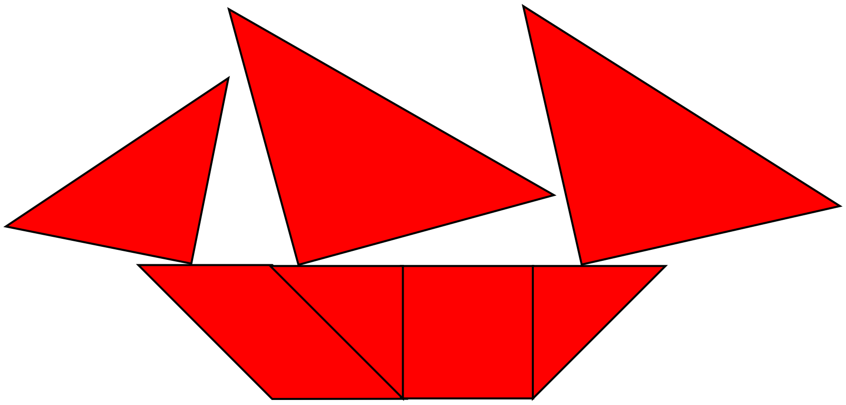
We can make many geometrical shapes by keeping these pieces next to each other that may require sliding, flipping and turning of the pieces. Make and trace the outline of following figures:
A square with two tangram pieces
A parallelogram that is not a rectangle with two pieces

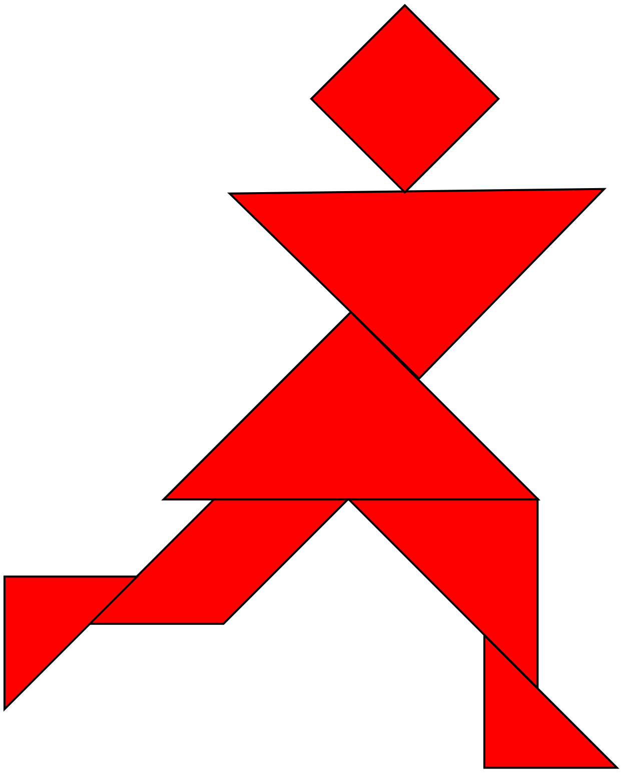
A triangle with two tangram pieces
A triangle with three tangram pieces
A square with three tangram pieces
A rectangle that is not a square with three pieces
You may work in groups of two or three to make as many different squares, triangles, rectangles that are not squares, parallelograms that are not a rectangle with four or more pieces and trace the outline of those.
Make some other geometrical shapes using two or more tangram pieces and draw an outline of those.
Fill the outlines of shapes made by others using tangram pieces.

Tangram puzzles

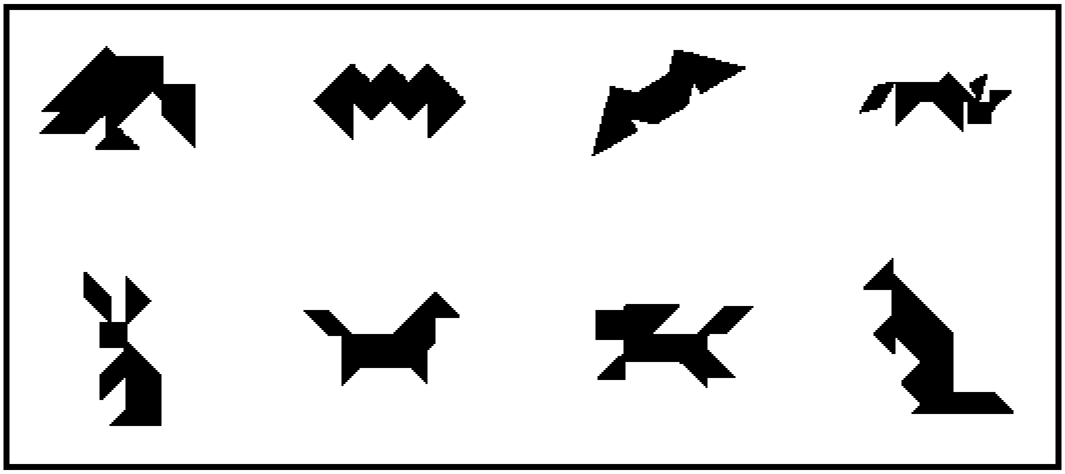
Make shapes given the outlines of figures using all the seven pieces. Some examples are given below



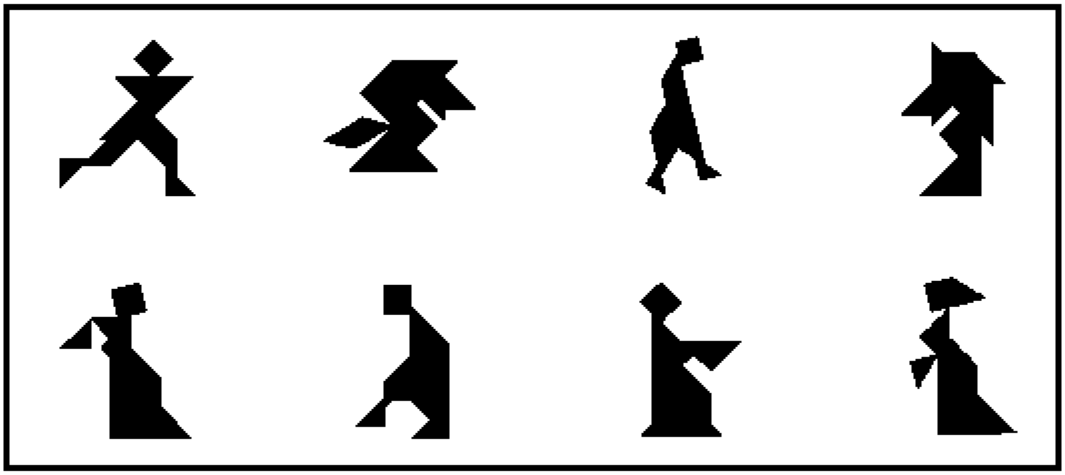




Websites given below provide the outlines of figures that can be filled by using all the seven pieces on line.
http:/pbs.kids.org/sagva/games/tangrams/index.html
http://standards.nctm.org/document/eexample/chap4/4.4/standalone1.htm
You can make many objects using these seven pieces such as animals, persons, letters etc. Many such figures are given in the website
http://www.geocities.com/TimesSquare/Arcade/1335/ani-02s.htm.
For those who may not have access to computer some figures from the above website are given below:



Animals



People

Make some of these (The solutions are given in Appendix 2) and draw their outlines.

Make some new shapes and draw their outlines.

Fill in the outlines of shapes made by others using all seven tangram pieces.

Symmetry

Symmetry

An object has symmetry, if when you draw a line down the middle, the left side is a mirror image of the right side.

Find out how many lines of symmetry do the square, medium sized triangle and parallelogram have by tracing and cutting these and folding them.

Trace the tangram pieces, flip these along a side and trace again. Draw the line of symmetry treating the tracing and tracing of the flipped figure as one figure.

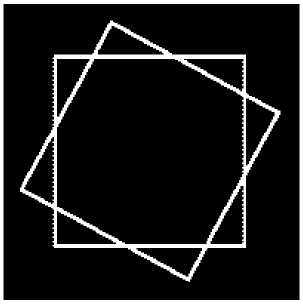
Compare your figure with others sitting next to you.

Rotational symmetry

We have rotational symmetry if we can turn a shape around a point (centre of symmetry) into one or more different positions during one complete turn that look exactly the same.

Activities

Trace and cut a square. Make another copy of that. Now you have two identical squares. Keep one square on the other so that it fits it exactly. Hold a pin in the centre with one hand and turn the paper on top slowly and count the number of positions in a complete turn, where it fits again. What was your count? (4), this count is called the **order of rotational symmetry.**



Similarly find the order of rotational symmetry of other tangram pieces.

Tiling a region

Tiling refers to filling a surface by shapes so that there are no overlaps or holes. It may not fill the corners.

Tile a page by drawing around a square tangram piece, slide the square so that its edge is along the side of square and draw around it again. Continue in this manner until the page is tiled. Make sure there are no gaps or overlaps.

Repeat it with a parallelogram.

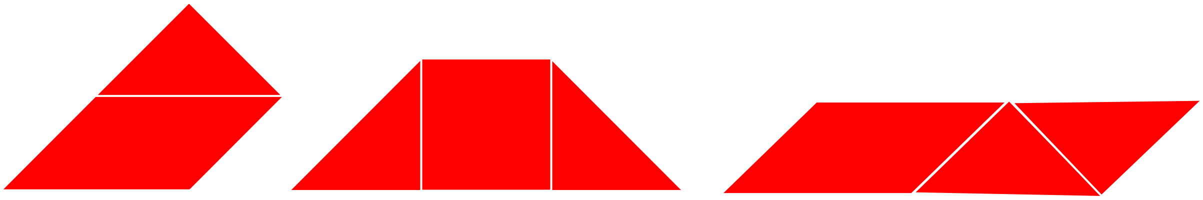
Can you tile a page by the triangular pieces so that there are no gaps or overlaps? If yes, tile it, if no, why?

Perimeter

If the length of a side of square is taken as a unit and the length of larger side of the smallest triangle is 1.4, what are the lengths of sides of the square, sides of smaller triangle, medium triangle, larger triangle and parallelogram?

(Hint: Cover the large figure with small triagles

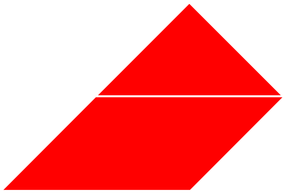
Find the perimeter of the figures made with tangram pieces.

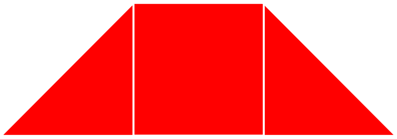


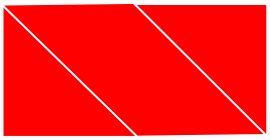
Areas

In all the questions given below let the square tangram piece represents one unit of area

1. Make a square with the two small triangles. What is the area of this square? How did you find out?
   What is the area of the small triangle used? How did you find out
2. Make a (non-square) parallelogram with the two small congruent triangles. What is the area of this parallelogram? How do you know?
3. Find the area of medium sized triangle. How did you find it out?
4. Find the area of largest triangle. How did you find it out?
5. Make a square with all the pieces. What is the area of this square? How did you find out?
6. Take the smallest triangle is taken as unit of area, find the area of all the tangram pieces.
7. Find the areas of figures made with tangram pieces such as these given below if the smallest triangle is taken as unit of area:



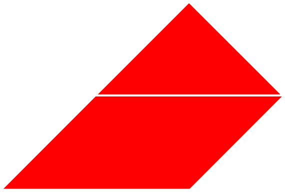


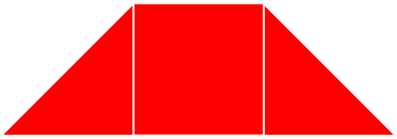


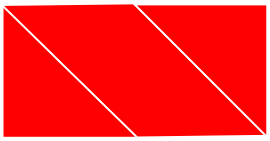
8. Find the area of a square made with all tangram pieces.
   (If you can not make a square with all pieces, see Appendix 1)
9. Find the area of any figure made with all tangram pieces.
10. Taking small triangle as a unit of area, make figures using two or more tangram pieces that have areas such as 1, 2, 3, 4, 6, 8

Fractions

Make a square with all seven pieces if that square represents 1 unit, which part of the square are the following tangram pieces:
Large triangles (1/4)
Square (1/8)
Small triangles (1/16)
Medium Triangle (1/8)
Parallelogram (1/8)
Repeat using another unit of area such as a large right triangle as 1 unit in area.
Find the areas of the following figures if the square made with all the tangram pieces represents 1 unit.





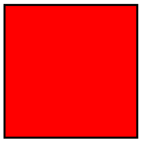


If the square made with all the tangram pieces is taken as a unit, make as many figures as you can by using any tangram pieces that have the following areas:

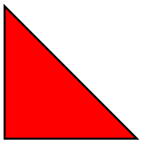
$\frac{2}{16}$ $\frac{3}{16}$ $\frac{4}{16}$ $\frac{8}{16}$ $\frac{1}{4}$, $\frac{2}{4}$ $\frac{2}{8}$, $\frac{3}{8}$

Comparison of fractions

If the square made with all the tangram pieces represents 1 unit, the tangram pieces represent the part represented by the fraction given below these.



1/8



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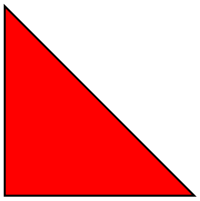

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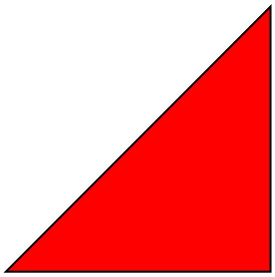


1/4

Compare the following fractions by writing >, <, or = between them

1/4 1/8

1/8 2/16

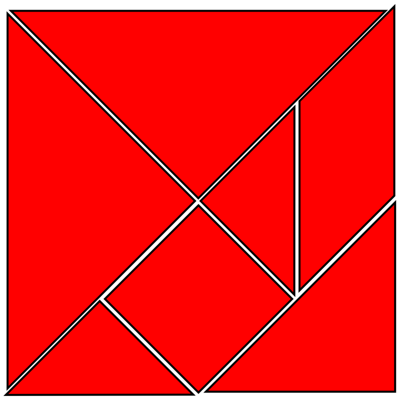
1/8 1/8

3/8 3/16

2/8 1/4

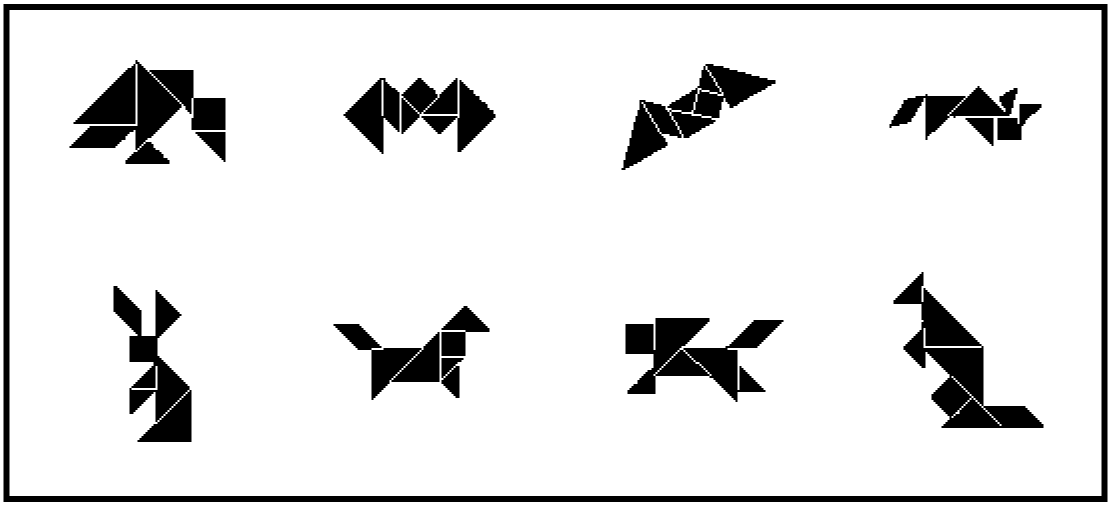
Appendix 1

Tangram



Appendix 2

Solutions to tangram puzzles



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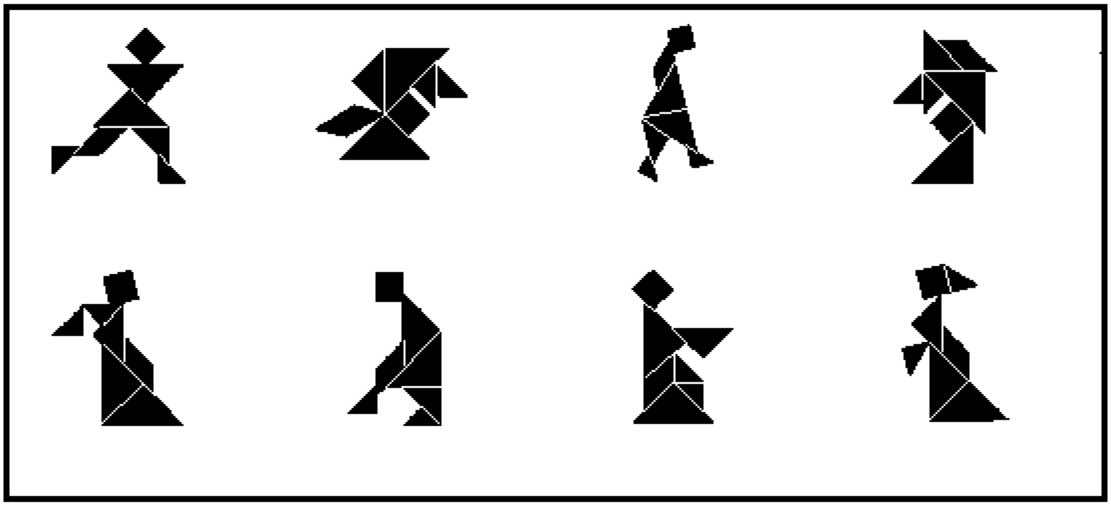

People